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C O T T O N R E S E A R C H

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A REVIEW OF THE RESEARCH PROGRAM RELATING TO COTTON

CARRIED ON BY THE

U. S. DEPARTMENT OF AGRICULTURE

AND

STATE AGRICULTURAL EXPERIMENT STATIONS

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Cotton Research
of the
U. S. Department of Agriculture
and the
State Agricultural Experiment Stations

This report contains, in summary, a statement of the primary objectives of active segments of research on cotton. The work has been classified according to the various functions in production, marketing, and utilization. A brief statement has been made of the problems involved and the lines of research which are directed to the prevention or correction of unfavorable conditions. Since the cotton research program is largely cooperative between the Department and the cotton States and many of the problems are approached on a regional basis no attempt has been made to identify each segment of research with a Federal agency or State. An attempt has been made to outline the current research program. Although marked progress in cotton research has been made during the past 10 years no attempt has been made to present an adequate record of this except as it may be useful in introducing the purpose of current work. Although it is impossible for one individual to have a comprehensive grasp of all of the problems confronting cotton or the full significance of each segment in the research program, an attempt has been made to point out some of its strength and some of its weaknesses. The observations are based upon a review of the research project outlines and current reports of progress.

Recent appropriations for agricultural research have provided funds and authority to attack agricultural problems on a regional basis, thus utilizing the technical resources of two or more States and the U. S. Department of Agriculture. The authority for organizing and planning regional research is broad and flexible to meet various situations. A record of the voluntary organizations set up to promote cooperative planning and coordination of cotton research should be of value as an introduction to this program.

Voluntary Coordination of Cotton Research

A research program involving 16 States extending north and south along the East Coast and across the continent on the south must adjust itself to many variables of climate; altitudes, soils, moisture, pests, and state interests. The problems involved have challenged agronomists, physiologists, geneticists, plant pathologists, economists, engineers, physicists, processors, merchants, finishers, and converters. Each of these perform a distinct and important function in the production and preparation of cotton for use. There exist common objectives which give them interlocking interests. All are concerned that cotton may maintain its position as a useful fiber.

It is important that each group of specialists that seek to advance the progress of cotton be familiar with the objectives and programs of other groups. Frequently two or more specialists may combine their resources to make a concerted attack on the same problem. For example, agronomists and pathologists cooperate in the study of cotton seedling diseases and the entomologist and engineer cooperate to develop effective spraying and dusting equipment to control insects. Industries that serve cotton production cooperate to supply better chemicals and mechanical equipment. Industries that use cotton products

are cooperating through their technical personnel and facilities to advance the use of cotton. Cotton growers cooperate in the use of their resources and through contacts with the programs are alert to new opportunities to improve production.

In the Cotton Belt small groups of those who represent related technical interests in cotton have formed voluntary organizations to facilitate research planning, to exchange information on research results and to review the progress of cooperative programs. In some of the regional programs Federal and State groups have joined in the selection of one individual to act in the capacity of a technical secretary to receive and distribute technical progress reports, to visit various segments of the program and make suggestions which will contribute to the establishment of comparable procedures and measures and strengthen the whole program. These cooperative groups meet at a central point to review the progress, exchange information and make such revisions in the program as seem necessary. Some of the cooperative groups that contribute to the planning of cotton research and to the dissemination of information are classified and listed below.

Production

S-9 Introduction, multiplication, preservation, and determination of potential value of new plants for industrial and other purposes, and the preservation of valuable germ plasm of economic plants. (A.R.S. and cotton States; private breeders)

S-1 Genetics and cytology of cotton. Research and plant science for the improvement of cotton. (Basic studies of cotton genetics and cytology) (La., Miss., N. C., Tenn., Tex., and N. Mex.; A.R.S.)

Steering Committee for Winter Planting Services in Mexico. (To accelerate cotton genetics and breeding by growing a crop during the winter months.) (Open to all cotton growing States; A.R.S.; National Cotton Council; and other industry groups.)

S-18 Weed control investigations in the South. (A.R.S. and cotton States.)

S-19 Plant parasitic nematodes. Chemical control and resistant varieties. (Ala., N. C., and A.R.S.)

W-24 Improvement of mechanized production and harvesting of irrigated cotton in the arid and semi-arid West.

S-2 The mechanization of cotton production, harvesting, ginning, and cleaning. (A.R.S. and cotton States.)

Long Staple Cotton Committee (Extra long staple cotton production and quality problems) (Ariz., N. Mex., and Tex.; A.M.S. and A.R.S.)

Cotton Improvement Conference (Agronomy of cotton, particularly breeding) (All cotton States, commercial cotton breeders, and A.R.S.)

Cotton Disease Council (Major cotton diseases of the Cotton Belt)
(Practically all cotton-growing States and A.R.S.)

Committee on Cotton Seedling Diseases (Cotton seed treatment and selection)
(Practically all cotton-growing States and A.R.S.)

Cotton Abscission Research Conference (Chemical defoliation and causes of bloom and fruit shedding) (Calif., Ariz., Tex., Miss., Ark., and A.R.S.)

Beltwide Cotton Defoliation Conference (Chemical defoliation) (All cotton States except N. C., Fla., and N. Mex.; A.R.S., A.M.S., and Civil Aeronautics Administration)

Spinner Breeder Conference (Sponsored by the Advisory Research Committee of the Delta Council) (Breeding and spinning of cottons, variety performance, maintenance of identity, and marketing) (Most of the Cotton Belt, A.R.S., A.M.S., cotton breeders and the textile industry)

Insect Control Section of Statewide Cotton Committee of Texas (Texas, A.R.S.)

Marketing

SM-1 The regional marketing of cotton, cottonseed, and cottonseed products
(Cotton States Marketing Service and A.R.S.)

Cotton Merchandising Clinic (Merchandising of cotton and methods of objective evaluating of the physical properties of cotton) (Cotton producing States, though mainly Tex.; A.M.S., A.R.S., cotton merchants and manufacturers)

Utilization

Cotton Fibers and Lint

Collaborators for the Cotton Fiber Division, Southern Utilization Research Branch.) (S.U.B.; A.R.S.; and processors)

Collaborators for Cotton Chemical Processing Division (Cotton chemical finishing)(Southern Utilization Research Branch and cotton processors)

Textile Research Institute Cotton Research Project. Research Advisory Committee (Cotton fiber quality and spinning performance) (A.R.S., A.M.S., textile industry research group)

Cotton Research Clinic (Cotton fiber quality and processing research)
(A.R.S., A.M.S., National Cotton Council, Textile Schools of N. C. and S. C.)

Collaborators for the Cotton Mechanical Processing Division (Research program of the Cotton Mechanical Processing Division, Southern Utilization Research Branch, Ala., Ga., S. C., and N. Y.)

Collaborators on Cotton and Cottonseed Research, National Cotton Council,
(Southern Utilization Research Branch and National Cotton Council)

Oilseed Collaborators (The oil seed program of the Southern Utilization
Research Branch) (Southern Utilization Research Branch and cottonseed
processing industry)

Technical Advisory Committee, National Cottonseed Products Association
(Research on cottonseed, particularly that in cooperation with National
Cottonseed Products Association and the Southern Utilization Research
Branch)

Cotton Seed Processing Clinic (Oil seed processors' problems, cottonseed,
and cottonseed products) (Cotton oil mills and equipment manufacturers,
A.M.S., and A.R.S.)

Working Group in Improving Nutritional Properties of Cotton Seed Meal
(Relation of processing to nutritive values) (Cotton states, A.R.S., and
A.M.S., cottonseed processors, and feed manufacturers)

Soil, Water, and Fertilizer Research Associated with Cotton Production

When representatives of the U. S. Department of Agriculture and the State
experiment stations of the cotton States outlined a research program for the re-
gion in 1946, the general statement of objective suggested that: "In developing
agricultural research in the Cotton South the program should be so organized
that no matter to what degree cotton remains in the picture, Southern agriculture
will be headed in the right direction. This will be true only with a sound
system of soil management and use, based upon adequate cover, green manuring,
rotations, fertilization, tillage and erosion control fitted to the different
soils." Though considerable change and much progress has been made this state-
ment still outlines a sound basis for research in the region. Research directed
to the development of a better understanding of our soil and water resources and
the principles underlying their conservation and use was considered basic to such
a program.

The classification and mapping of soils and the associated work on soil
origin, structure, and composition have developed improved techniques for the
study of soils, their use and conservation. All of the cotton States and the
Department are cooperating in the soil surveys. The soil maps and associated
information are increasingly used in the planning of research and are in the
projection of operational and educational programs.

Progress has been made in the study of mineral deficiencies of soils by
direct examination, by plant indicators and chemical analysis, and by feeding
plants grown on them to animals. Such studies have been particularly active in
the Coastal Plains of the Southeast where valuable information has been collected
on the need for added phosphate, calcium, magnesium, copper and cobalt to improve
plant growth and minerals required by growing animals.

Records of fertilizer usage in the cotton States indicate marked increases in total tonnage applied and in its plant food content. Taking the period of 1935 to 1939 as a base period, the National Fertilizer Association has estimated the increased consumption in 1950 at 180% in South Carolina, 200% for North Carolina, Georgia, Alabama, and Texas, 300% for Oklahoma, Arizona and New Mexico, and 400 to 800% for Tennessee, Mississippi, Arkansas, and Florida. The increased consumption has been due in part to favorable prices for farm products and fertilizers and to research information that has been made available. Recent droughts and other unfavorable weather conditions have indicated that fertilization pays best in association with conservation farming.

Many of the soil studies are concerned with the basic properties of the important soil types and their relationship to plant growth and reproduction. Studies of fertilizer requirements are extended to pastures, forage crops, small grain and corn as major or supplemental enterprises in the area. The program includes studies designed to correlate soil classification with chemical and physical properties of the soil, the relation of soil types to the availability of nutrients, chemical methods for diagnosing mineral deficiencies of plants, the relation of ion exchange properties of soil to the use of added nutrients by plants, and ionic reactions in clay and soil systems. Some of the studies are concerned with the behavior of fertilizer elements which may be naturally deficient or depleted by past cropping. They seek to learn more about the behavior of potassium in the soil and to determine optimum levels. Other studies are concerned with the factors which affect the nature and behavior of native and added phosphates and the relationship between potassium, sodium, calcium, magnesium and other minor plant nutrients of Coastal Plain soils. The soils research program is also concerned with the effects of lime on its physical and chemical properties and availability of plant nutrients. Studies are concerned with the nature of the soil microflora and their activity as affected by temperature, moisture, salinity, etc., the production of available nitrogen by fungus, and the mechanisms involved in the gains and losses of nitrogen in soils. Direct studies of the physiology of the cotton plant with special reference to its requirements for sulphur and the translocation in the plant are under way. Other physiological studies are concerned with the ratio of balance between leaf produced auxin and boll produced anti-auxin to boll shedding. The cotton States and the Department are limited in technical personnel and facilities to do the required basic soils and physiological research needed in this area.

During the past 10 years all areas of the Cotton Belt have shown a slight reduction in the acreage of peanuts with increased yield per acre. The Southeastern States with the exception of Tennessee have experienced a decrease in cotton acreage and an increase in yield per acre. The Southwestern States have increased acreage and yield per acre in areas where irrigation is available. During the same period there has been a slight reduction in the total acreage of tobacco with increased production per acre. Some of these shifts were anticipated and research programs were planned to provide alternate sources of income within a soil conservation program.

Studies directed to the aid of these adjustments are concerned with physical properties of soils as related to cropping practices and accompanying yields of row cultivated crops, pasture and forage crops. Rotation and fertilizer studies with cotton on heavy Delta soils seek to measure returns and residual value of perennial legumes for soil improvement. The value of vetch turned under as a source of nitrogen is being measured in terms of equivalent of commercial nitrogen. Various rotations and crop residue management variations are studied with reference to their protection against soil erosion. Cropping systems and tillage methods are studied as means of conserving water and soil and to measure their contribution to organic matter and nitrogen. Attention is also being given to surface and subsurface drainage in relation to conservation. These objectives recognize the common problem of conservation where a large percentage of the land is cultivated to row crops. The solutions must be found under varying conditions of soil, climate, and crop adaptations.

In support of the above programs are studies which seek to establish known legumes and grasses to suitable cropping systems and to develop new grasses and legumes suited to specific purposes. These studies include methods of seeding and fertilization of permanent pastures on various soil types to maintain desirable plant composition and practical phases of seeding and fertilizing to establish permanent pastures. Soybean varieties suited to the several areas of the Cotton Belt have been developed through State and regional cooperation of the Department. Other forage crop studies include annual and perennial lespedezas suited to different areas and resistant to nematode, and the development of more palatable strains of the sericea lespedeza. Future progress of agricultural adjustments in the cotton States is dependent upon the progress made in this area of work. Present personnel and facilities are inadequate for this task. The lack of suitable grasses and legumes and methods of culture has limited the effectiveness of past efforts for soil conservation.

Changes in Practice

Some measure of the effectiveness of research operations and extension in changing the position of cotton and alternate enterprises in the region should be of value. An appraisal of available information and current methods seems essential. A table is inserted here to show the trends in cotton acreage, using the period of 1936-40 as a base period, and including years individually, and the average for the period of 1951-53. The extent to which adjustments have been retarded by price supports is not known but we know it has had a marked influence. Reduction of acreage has occurred in North Carolina, South Carolina, Georgia, Alabama, Mississippi, Louisiana, and Oklahoma. Increases in acreage have occurred in Texas, New Mexico, Arizona, and Missouri. In many areas cotton has yielded a smaller portion of the total income.

Cotton Acreages in Cultivation July 1
By States and Averages For Certain Periods.*

State	Average 1936-40	1947	1948	1949	1950	1951	1952	1953	Average 1949-53	Average 1951-53
North Carolina	897	654	742	869	thousand acres 601	698	753	770	738	740
South Carolina	1,358	1,055	1,123	1,283	879	1,075	1,109	1,080	1,085	1,088
Georgia	2,163	1,278	1,295	1,618	1,054	1,424	1,439	1,365	1,380	1,409
Tennessee	784	704	773	845	644	805	841	905	808	850
Alabama	2,211	1,505	1,637	1,825	1,327	1,469	1,556	1,590	1,554	1,538
Mississippi	2,798	2,379	2,583	2,859	2,084	2,463	2,399	2,430	2,447	2,431
Arkansas	2,405	2,085	2,335	2,616	1,728	2,189	1,910	1,835	2,066	1,995
Louisiana	1,268	838	957	1,077	739	949	899	920	917	923
Oklahoma	1,977	1,155	1,069	1,344	965	1,561	1,283	1,045	1,240	1,296
Texas	9,982	8,426	8,806	10,988	7,048	12,407	11,756	9,600	10,360	11,254
New Mexico	114	157	215	323	176	328	310	320	291	319
Arizona	224	226	282	401	280	548	669	678	515	632
California	401	536	810	963	586	1,331	1,407	1,404	1,138	1,380
Missouri	422	440	563	604	449	570	495	515	527	527

*California Agr. Exp. Station Report 161, 1954

Since the acreage of cropland used only for pasture gives some measure of the use of protective cover and shifts to livestock enterprises a table has been included on the acreage of cropland used only for pasture. The records indicate a gradual increase in acreage of cropland used for pasture during the period of 1925 to 1940. Since that time there has been some reduction of acreage in all of the cotton States, although some of the States have shown very consistent gains between 1925 and 1940. Some of the Southeastern States have found other uses for land taken out of cotton and States of the Southwest with the exception of Texas have increased cotton acreage without materially reducing the acreage of cropland used for pasture.

Cropland Used Only For Pasture
Acres

State	1950	1940	1935	1930	1925
North Carolina	732,664	1,230,171	946,260	887,956	881,893
South Carolina	494,385	604,350	356,922	350,839	310,566
Tennessee	2,855,786	3,547,298	3,015,451	2,751,200	2,588,462
Georgia	1,273,027	1,374,719	2,174,347	2,109,452	2,568,240
Alabama	1,598,354	2,173,731	1,363,326	1,203,622	1,129,151
Mississippi	1,604,183	2,702,190	1,903,301	1,495,294	1,412,430
Louisiana	1,803,849	1,442,636	1,119,597	915,839	784,503
Arkansas	2,471,912	2,541,909	1,491,920	1,169,961	956,359
Oklahoma	2,317,778	3,830,147	2,562,122	3,248,518	3,878,644
Texas	6,642,546	13,242,974	7,786,697	11,156,355	13,617,251
New Mexico	2,317,778	2,562,122	3,248,518	3,878,644	-
Arizona	184,010	261,499	159,940	102,123	-
California	3,350,589	4,242,598	2,967,526	3,075,362	3,033,414

U. S. Census 1950

A second measure has been used to estimate changes in livestock production in individual cotton counties of the Cotton Belt. Counties producing 20,000 or more bales of cotton were selected. Beginning in North Carolina a random sample of counties was taken from counties of the Coastal Plain and the Piedmont area of each of the Southern States and from cotton counties of the Southwest and West. From the U. S. 1950 Census records of total farm income, income from crops and income from livestock and livestock products, the percentage of total income from livestock was calculated for the years 1944 and 1949. The data for 1944 has been recorded in the attached chart. The counties are arranged in the order of magnitude of the percentage income from livestock and livestock products. The percentage of income from livestock and livestock products for the same counties in 1949 is charted in terms of percentage, increase or decrease, of the 1944 values. It is evident that some counties have not chosen livestock as a supplemental or alternate enterprise. Others have made considerable change in the size of their livestock enterprise. In the Southwest livestock income has been supplemented with cotton. Counties in the Southeast that have for several years been established in cotton and tobacco have the minimum of income from livestock and have made the least change toward livestock production. Counties of the Southwest and West show a smaller percentage of the total income from livestock due to the magnitude of income from cotton in 1949, although the total value of livestock sold was much greater in 1949 than in 1944.

Percentage of Total Farm Income
From Livestock and Livestock Products
In Selected Cotton Belt Counties*

1944	1949
3.1	4.1
3.4	4.3
4.0	19.6
7.0	14.3
9.1	20.2
9.4	17.7
10.	31.
11.5	12.3
13.37	29.6
14.29	17.9
14.3	20.0
15.6	19.9
15.8	27.6
16.3	16.3
16.4	20.6
17.8	28.2
18.3	19.0
19.5	13.1
20.9	29.6
21.2	17.9
24.3	27.0
27.3	15.8
28.4	31.9
28.5	11.2
30.2	30.8
33.9	50.0
35.3	46.8
36.7	40.0
37.7	40.2
39.5	28.5
40.4	45.5
42.0	54.7
45.2	52.8
96.9	53.7

*Based upon U. S. Census of Agriculture 1950

The Alabama Agricultural Experiment Station* has recently made studies of changes in cotton production in areas of the State. The changes are summarized as follows:

1. In the Limestone Valley area cotton acreage has been reduced 50 percent during the past two decades and the average annual production has been maintained.
2. In the Sand Mountain area the acreage has been reduced 25 percent and the reduction has been more than offset by increased yields.
3. In the Piedmont area the harvested acreage has been reduced almost 73 percent, the average production per acre has been increased 100 pounds, and the total production decreased more than 50 percent.
4. In the Upper Coastal Plain area the acreage has been reduced 52 percent and production reduced only 20 percent.
5. In the Lower Coastal Plain cotton acreage has been reduced more than 74 percent and the reduction in production 54 percent during the past twenty years.
6. In the Black Belt area the acreage of cotton has been reduced 70 percent although the total yields have not changed this much.

Lee and Aull have gone a step further in a study of "Land Use and Conservation in the Broad River Conservation District of South Carolina in 1944." They report that "Cotton acreage has been reduced to about one third of the peak acreage which occurred in 1929. Only about 40 percent of the reduction, however, has been shifted to small grain, hay, pasture, or other types of conservation farming. About one third of the reduction is accounted for by land which has gone out of agricultural production. The remainder has been shifted to other intertilled crops, such as orchards and sweet potatoes.

"On small farms the enterprises carried on will tend to be those which will provide the greatest amount of work to the labor force available to work on the limited acreage in the farm. This is one economic and social problem which makes it impossible for many farmers to make shifts in the interest of soil conservation. Shifting to extensive systems of land use on small farms results in lowered income to the operator and his family."

I shall not seek an argument with the economists on this point but it does seem essential that small farms practice soil conservation. More can

*Alabama Agricultural Experiment Station
Circulars 100, 101, 102, 103 and 104.

be done in conserving the land on small farms and some small farmers are practicing such methods. They need better legumes and more information to reduce their hazards.

Economics of Cotton Production

Farm Organization and Management. Farm organization and management studies have sought to measure changes in production adjustments and to determine profitable organization under existing conditions. The studies are concerned with present and alternative farming systems in areas where cotton acreage has been declining and substitute enterprises are being sought by the growers. In South Carolina studies are made of the possibilities of increased use of improved pastures in livestock systems and the economics of pasture and forage utilization as a substitute for cotton. Other studies seek information on labor, power, and materials used in the production of cotton on farms differing in size and type of power. Studies of costs and returns on combination cotton and tobacco farms, on small-scale and commercial family-operated farms, on small cotton farms and large-scale cotton farms and on farms where cotton and peanuts are grown. Important studies are being made of the possibilities of enlarging small upland farms and its influence on farm organization and returns under varying economic conditions. In projecting some of these studies the leader outlines possible economic changes that the cotton grower may be confronted with, as "(a) increased competition from synthetic fibers, (b) decrease or loss of foreign markets, (c) rising wage rates and smaller farm supply, and (d) inability to mechanize cotton production through all operations."

Recent studies on "Organizational Problems on Small Farms in Northern Louisiana" by the Louisiana Agricultural Experiment Station reports that "It appears from the analysis of various factors affecting profits in farming among the major types of enterprise combinations found in Union Parish in 1950 that the most suitable combination of resources for the price-cost relationship which existed in the area at that time rank in the following order of preference:

1. General farming (No dominant commodity to the extent of 40 percent)
2. Livestock, Poultry and Truck Crops
3. Dairy farming
4. Cotton and truck crops
5. Livestock, Poultry and Cotton "

Economics of Cotton Production Practices. Current statistics on the planting, production and disposal of cotton by qualities furnish a useful basis for planning production and marketing. Economic studies of farm practices in the production of cotton and associated enterprises furnish a measure of those practices which are sound and help to guide planning for the future.

Such studies include the collection and analysis of information in farm labor requirements, equipment, farm supplies and changes in farm practices as they relate to production efficiency. Similar studies are applied to the survey of extent to which spraying and dusting are used for pest control, their costs and returns. Costs and returns from types of

cotton farming are made on farms where cotton and tobacco are grown and in other areas where cotton and peanuts are the principal enterprises. Comparative cost and returns studies are made on small-scale and large-scale farms of the Southern Piedmont and the Delta areas of Arkansas, Louisiana, and Mississippi. Some of these studies are applied directly to an understanding of current labor-saving devices, their effects upon farm organization, operation and income on farms of various types, sizes and physical resources.

The hazards associated with cotton production are being appraised through the economic studies of the significance of weather fluctuations and other production risks. This research is also designed to measure local hazards, their influence upon farm income and the extent to which yield variability is reflected in land values. The information will be used to suggest method of protection which will improve the stability of farm income.

The work on cotton statistics includes estimates and reports on cotton acreage, yield per acre, production, stocks, farm disposition, domestic use, export and other related data. Associated studies are directed to the improvement of methods for collecting statistics to make them more accurate. Since much of our cotton is exported and the outlets are influenced by production in other areas of the world it is essential that we keep informed regarding cotton production and consumption in other parts of the world. Such statistics are collected on the production, quality, distribution and consumption of cotton and other plant fibers. These studies are made from available current statistics and by personal visits of members of the staff to the principal producing and consuming areas.

Cotton Genetics and Breeding

Differences in available moisture, length of growing season, soil types, altitude, plant pests, and other environmental conditions under which cotton is produced impose varying demands upon the plant. One strain of cotton could hardly be expected to be adapted to all of these conditions. Intensive regional breeding is required to provide high yielding strains which produce good quality lint in the humid East, in the West with and without irrigation, at high and low altitudes, and under differences of light intensity and length of day. Strains are needed that are immune or tolerant of various airborne, soilborne, and seedborne diseases. Certain types of growth and fruiting are required to facilitate the operation of mechanical equipment for planting, cultivating, harvesting, and cleaning. These are some of the conditions for which adapted strains of cotton are sought.

Among those who contribute to this program are plant explorers who collect wild species and domesticated types from all parts of the world where cotton and its related species are grown. Botanists and geneticists preserve these plant materials and study their physical and biological characteristics. The plant materials represent several species, many of them relatively useless in themselves unless they possess valuable qualities that can be transferred to commercial varieties by hybridization. In some cases it is necessary to disturb the normal mechanism of reproduction by the use of chemicals or

or X ray to produce compatible lines. Such procedures have made possible the transfer of properties that do not naturally occur in domestic varieties.

A group of geneticists are preserving homozygous lines of cotton of known source and history and are studying the inheritance of their genetic components when differing lines are crossed. These studies of the modes of inheritance are basic to the use of collected blood lines. Members of this group are also engaged in studies to improve breeding methodology and techniques.

Considerable effort is being devoted to the use of the above information and materials in the development of new and improved varieties. In the Department cooperation in this program the Cotton Belt is divided into sub-regions. These include the Southeast, where cooperative work is directed to the development of strains having high tensile strength of fiber and bacterial blight resistance. In the Mid-South bacterial blight resistance, coarser fiber, and Verticillium wilt resistance are sought. For the Blacklands and Plains areas of Texas and Oklahoma storm-proof, bacterial blight-resistant strains with earliness for the high plains are desired. In the irrigated area of the Southwest efforts are directed to improvement in the productivity of Hopi Acala, self defoliation at maturity, and bacterial blight resistance of improved strains of Acala. Work on American Egyptian Pima seeks to improve the length and strength of fibers. Improved Sea Island stocks are preserved pending the commercial need for this type of cotton. Other objectives include the development of new general-purpose cotton strains superior to existing varieties, resistant to disease, and suitable in length to meet commercial demands. To facilitate phases of this program the National Cotton Council has cooperated in providing land in Mexico where strains may be grown during the winter months, thus shortening the developmental period.

The establishment of one-variety communities to standardized uniform production has been closely associated with the breeding and improvement programs. In recent years much progress has been made in the Southeast, the Mid-South, and certain states of the Southwest in reducing the number of cotton varieties and in the establishment of large one-variety areas. California was one of the earliest states to adopt this method of standardization.

Comments on Cotton Breeding Program. The cotton breeding program appears to contain a large number of projects with the primary aim of developing improved varieties of cotton. The outlines in some cases indicate selection and inheritance studies but the reports are primarily concerned with new varieties developed rather than the advancement of knowledge of the genetics of the crop. Eighteen projects are classified in this group. It would appear advisable for institutions in the Cotton Belt to develop private breeders to render this service and have the research staff apply more of their efforts in the study of inheritance of economic qualities.

The one-variety community program has been demonstrated as a feasible program. Consideration should be given to its transfer and continuance by the Agricultural Extension Service since it has no direct function in research.

Cotton Quality

The advancement of basic knowledge regarding the chemical and physical properties of cotton fibers has been an outstanding contribution to cotton and cotton technology during the past decade. This research was initiated as a means of improving the competitive position of cotton with synthetic fibers and to make it more useful to the consumer. Much of the new knowledge has been correlated with commercial use. The new methods of measuring cotton properties have been adopted by breeders, by cotton merchants who seek to supply the manufacturers with uniform lots of cotton, and by the manufacturer for improving or maintaining his standard of output. This phase of the quality studies will be given further consideration as it relates to utilization. It should be stated here that the studies of cotton qualities in the breeding program are thoroughly integrated with related studies associated with the development of cotton grades and standards and those associated with utilization of the fiber. New plant introductions are studied to note any unique fiber characteristics and new lines derived from selections, and recombined qualities are submitted to establish fiber tests for length, strength, fineness, cell wall development or maturity, and other properties.

Records of plant families, when carefully analyzed from season to season, increase our understanding of the inheritance of fiber properties and give a better measure of seasonal influences. Carefully controlled studies are directed to the improvement of tests for measuring tensile strength of fibers and the correlation of these measures with yarn strength. Some of the studies are concerned with the relationship of the minute structure and chemical composition of fibers to fiber physical properties and spinning values. Means of determining the nature of attack upon fibers by microorganisms are sought. The use of chemical defoliants to remove cotton leaves in preparation for mechanical harvesting is being investigated to note the influence of time of defoliation upon fiber properties and spinning quality.

Comments. It would appear that the techniques for measuring properties of fibers have advanced more rapidly than the techniques used to correlate these values in terms of spinning, weaving and utility. It has been difficult to isolate lines that vary only in the magnitude of a single property. Present experimental spinning techniques are not sufficiently precise to test the value of some of the measured properties and correlation values may prove misleading.

Cotton Diseases

Cotton diseases take a very heavy toll from the cotton crop through reduced stands, impaired productivity and depreciation in the value of the lint. Plant pathologists, geneticists and agronomists seek to develop a better understanding of the nature of cotton diseases and means of prevention. Diseases attack the seedlings, the growing leaves and branches, the buds, the bolls, and the root system. In some of the programs joint studies are planned and in others the work is done by the agronomist or plant pathologist with occasional consultation. The value of joint planning and joint

execution of such programs is evident.

Among the diseases most frequently mentioned are Verticillium wilt, Fusarium wilt-nematode complex, bacterial blight, anthracnose and rhizoctonia. Verticillium albo-atrum, a serious soilborne disease of the Southwest, is reported to have been responsible for losses amounting to more than 2,000,000 dollars during a single season in New Mexico. No practical treatment has been found and no domestic varieties have been found immune to the disease. Strains selected in California have shown some measure of tolerance and are being used for further study. The seed of diseased plants are being examined to determine whether the seed may be infected through the conducting tissues of the plant or otherwise. Strains of cotton of Gossypium barbadense origin have shown more tolerance of the disease than the domestic varieties from G. hirsutum. Other studies are designed to determine the influence of cultural methods, thickness of planting, time of planting, relation of soil moisture and temperature, the use of fertilizer and soil amendments and the influence of crop rotations. Soil disinfection by the use of chemicals and gases is also being tested as a means of control. The recent report to the Cotton Advisory Committee calls attention to the serious losses due to this disease and suggests accelerated research to combat it. The report does not indicate the phase of the program that should be strengthened.

Fusarium wilt, another soilborne disease which attacks the cotton plant particularly in the Southeast, has met with some control through the breeding of resistant varieties. New resistant varieties have recently been released and are showing marked resistance to the disease. Development of resistance has been a complex problem because of the association of Fusarium wilt and nematode and the existence of biological strains of the wilt organism. Active studies of the forms of wilt and the host parasite relationship are continued. Soil fumigation studies are under way and new plant materials are being tested for resistance.

Progress has been made in the selection of cotton strains which show resistance to bacterial blight. The recent discovery of a more virulent strain of this disease necessitates the reconsideration of this problem since cottons previously established for resistance are found to be susceptible to the new strain of the blight.

Cotton seedling diseases due to soil-inhabited pathogenes are a source of considerable loss due to poor stand or retarded growth. These organisms are particularly destructive during cool spring weather. Seed treatments with fungicides have not been fully effective in the control of certain diseases such as Rhizoctonia solani. Isolation and inoculation studies under control conditions are being made of the pathogenes collected from diseased seedlings to determine their behavior under differences of soil temperature and humidity. Control measures are also sought through the use of new fungicides applied in the furrow and on the seed. Differences have been found in the tolerance of seedlings from certain varieties. These observations are receiving further study to test the possibility of selecting strains having resistance to seedling diseases, particularly Rhizoctonia.

Progress has been made in the development of practical control measures for Phymatotrichum Root Rot so important in the Blacklands of Texas. Changes

in cultural methods and rotations of crops have been so effective that less emphasis will be given to this phase of the disease program in future.

Comments. While much progress has been made in the advancement of basic knowledge of cotton diseases the program has not been fully adequate. This has been due in part to lack of total support of research in this field and in part to the assignment of projects to members of the staff heavily loaded with teaching and other duties. This program should be reexamined by those most competent in the field with the purpose of planning a more adequate program in collaboration with other interested groups.

Cotton Insects

The cotton plant is subject to damage by a large variety of insects. Certain species attack the seedling and young stages and others follow until the plants are killed by frost or mechanical destruction. Some of them suck the plant juices, while others devour the leaves, destroy the flower buds and bolls, and attack the root system. In addition to their direct damage insects transmit disease organisms from diseased plants to healthy plants, causing increased damage from disease.

Much progress has been made in recent years in studies of the life history of cotton insects and their natural enemies including parasites and predators. Related studies have advanced our knowledge of the influence of poisoning and other agricultural practices upon the effectiveness of biological control.

In the past it has been difficult to measure the value of economic loss due to insect damage. New techniques have now been developed to supply a more accurate measure of the damage done and the relative advantage of using control measures. Progress is being made in the preparation of chemicals and the timing of applications to control more than one species at the time. Attention is also being given to the length of time during which insecticides are effective.

The past ten years have witnessed unusual activities in the development of chemicals suited to the control of insects. State institutions, the Federal Government, and industry have participated in this development. Much of the work has been cooperative and many of the developments have been accelerated through the collaboration of scientists in public and private agencies. Some of the developments were stimulated by needs of the war effort. Cotton production has benefitted from these discoveries. A brief summary of active research on specific cotton insects follows:

Boll Weevil. In terms of general distribution and total damage to the cotton crop the boll weevil would be designated as enemy number one. Studies for its control include surveys to estimate its distribution, abundance and damage, and to note the influence of cultural practices and chemical defoliation upon its survival. Extensive tests are being made of the toxicity of chemicals, their adaptability to mechanical application, and the persistence of their toxicity. Careful studies are made of the physiology of the boll weevil to discover weaknesses that may be used to advantage in its destruction. Basic studies are designed to relate atmospheric temperature, sunshine

and humidity conditions to the toxicity of insecticides. Parallel studies are made in the laboratory, in cages, and under field conditions. Hibernation studies are made in the fall and in the spring to determine winter survival. Survival records are correlated with environmental conditions to improve the accuracy of predicting survival and early infestation. Surveys are conducted during the growing season to complete these records and to advise cotton growers. In the States boll weevil research is usually conducted cooperatively by representatives of two or more departments, entomology, agronomy, botany, agricultural engineering and chemistry being those most frequently involved. Related studies are concerned with the phytotoxicity of insecticide chemicals to determine the possible influence of accumulated spray residues upon succeeding crops.

Bollworm. The bollworm of cotton is distributed throughout the Cotton Belt where it finds a large variety of host plants in addition to cotton. In the areas of heavy infestation the losses have amounted to 25 to 75 percent of the crop. The buildup of heavy infestations of bollworm has frequently been associated with the destruction of its predators and parasites by insecticides applied for the control of boll weevil and other insects.

Current research on bollworm is designed to explore the seasonal and geographical distribution of the different species, their host plants, the damage to cotton, the various parasites and predators, and the farm practices which may be of value in their control. In recent years considerable emphasis has been given to studies of their natural enemies and the ecological factors involved in destructive outbreaks of bollworm. The timing of insecticide applications to permit the development of natural enemies has also been studied.

Pink Bollworm. The pink bollworm is said to be the most devastating cotton pest and its area of infestation has been increasing in recent years. It has been a difficult pest to control. The threat from the pink bollworm is described by a Texas project leader as critical. He reports that "In 1952 the insect destroyed more cotton in the State than in all preceding 36 years combined. The South Texas area alone lost an estimated 28 million dollars worth of cotton in 1952 and infestations for the first time became general in the Lower Valley and the Coastal Band areas." The research program for the control of pink bollworm is conducted in cooperation between the Federal Department of Agriculture, the Mexican Government, States of the Southwest, and private interests.

Active research seeks to advance our knowledge of factors which influence winter carryover, seasonal abundance and spread of the insect. Basic information is being sought on the biology and ecology of the insect, migration, and flight habits. Related studies are concerned with the discovery of more effective cultural and chemical control measures, including stalk shredders and systemic insecticides. With the purpose of discovering possible weak points in the life cycle of the insect, studies are made of the nutritional requirements of the larvae with associated histological and morphological and chemical changes during its development. Biological control measures are also sought through the rearing and testing of parasites known to attack the pink bollworm in India. The use of mercury-vapor lamps with black filter is being tried as a trap to take pink boll moths at night and dielectric heaters are being tried as a means of destroying the insect in

cottonseed.

Control operations seek to determine the degree of infestation in areas under quarantine, to discover incipient infestations, to prevent spread into new areas, and to destroy the insect in the hibernating and active stages. This phase of the program is conducted in cooperation with the Mexican Government to prevent further spread and includes eradication of wild cottons in Florida to eliminate possible host plants where pink bollworm may establish itself.

The pink bollworm research program has recently received encouragement by the establishment of a cooperative laboratory at Brownsville, Texas and a sub-laboratory at Lubbock, Texas to make intensive studies of the pink bollworm and its control. The program includes studies of parasites and diseases as a means of control. The new facilities and personnel will give considerable impetus to this work.

Other Insects. Other insects of somewhat less importance than those described above include the cotton leafworm, cotton flea hoppers, salt marsh caterpillar, several species of aphids, spider mites, stink bugs, plant bugs, lygus bugs, cutworms, webworms, grasshoppers and flea beetles. Observations are being made on the host plant relationship, the effect of predators and parasites, the effects of insecticides applied for the control of other insects, and ecological factors associated with their multiplication and infestation. Effectiveness of commonly used insecticides is determined with each species and specific controls made available in case of sudden outbreaks.

Active studies are under way to determine the benefits derived from early season control of thrips, aphids, and other injurious insects. Related studies include surveys during winter and spring months to observe the abundance of aphids in wild and cultivated hosts as possible sources for cotton infestation.

Systemic Insecticides for Cotton. The use of systemic insecticides to protect plants from insect attack has opened an interesting field for basic research in the cooperative program. The study of the plant's role in the translocation, alteration and persistence of systemic pesticides offers new opportunities for plant protection. Explorations to discover the nature of foliar and root absorption, the influence of the chemicals upon plant nutrition and their effects upon cotton insects are of immediate interest. Preliminary studies have been sufficiently encouraging to pursue these studies further.

Beneficial Insects. Most biologists recognize in nature the balancing effect of organisms which prey upon other species. Insect species are held in check by predators and parasites. The use of insecticides has at times unbalanced this relationship and has been directly responsible for marked increases in certain species due to the elimination of their predators and parasites. Basic studies are being conducted to note the effects of the various insecticides upon these beneficial insects and the influence of timing of applications upon their survival.

Research to Improve Quarantine Techniques. Studies are directed to the improvement of techniques for treating plants and commodities regulated by plant quarantine whereby they may move in trade channels without danger of disseminating new or restricted insects. Methods of fumigating large quantities of bulk cottonseed and intercepted importations of cottonseed cake are being tested for effectiveness.

Mechanized Production of Cotton

Research for the application of mechanized equipment to the production and harvesting of cotton has been under way for many years, although the support for this work has been inadequate. In the planning of work that would be done under the Research and Marketing Act of 1946 this objective was included, particularly mechanization adapted to the operations of smaller farms. The participants in this program include representatives of the Federal Department of Agriculture, the State experiment stations, and the farm machinery industry. Representatives of these groups constitute the central steering committee for planning, for development of cooperative effort, and for the exchange of information. The program is well coordinated and cooperative.

The research program has included basic studies of the physical and mechanical requirements for performing each of the operations in cotton production and the testing of commercials and modified machines in the performance of the various tasks. This work seeks to simplify equipment by preparing designs that will find more general and flexible utility to reduce the cost of mechanization.

The program for the study of mechanization of cotton production is organized on a regional basis. An engineering specialist has been selected by participants in the program to correlate the various projects in the region and to act as a clearing house for new information. Segments of the program are concerned with the development of methods and machines for the disposal of crop residues and for seedbed preparation, the design and operation of machines suited to hill dropping of seed, and the improvement of equipment for cross plowing of cotton. Other studies are concerned with the mechanical application and effectiveness of pre-emergence and post-emergence herbicides and the use of steam and flaming for the control of weeds. Laboratory and controlled field studies are directed to the development of fundamental engineering information to guide the improvement of equipment and materials for controlling weeds, insect pests, and plant diseases through cultural methods, mechanical distribution, applications of liquid and dust herbicides, insecticides and fungicides from ground machines and aircraft.

Attention is being given the basic engineering requirements of machines needed to prepare seedbeds, distribute fertilizer, plant seeds and cultivate. The performance of machines in these jobs is correlated with mechanical harvesting studies so that the various jobs performed mechanically may be so integrated as to contribute favorable conditions for the one which succeeds it. Machines are being developed that may be used in the production of other crops than cotton. Cottonseed planting experiments include mechanical adjustments for the planting of machine delinted, chemical delinted and pelleted

seed when drilled and chopped to stand, when drilled to stand, and when hill-dropped to stand as they affect man-hour requirements, cultivation costs and yields. The use of the rotary hoe is being compared with the conventional methods of cultivation.

Industry and public research agencies have sought to reduce the labor costs of harvesting cotton by hand over a long period of time. Added labor costs and recent opportunities for new research in this field have accelerated this program. A group of active and coordinated projects are concerned with the development of new types of pickers and strippers and the modification of available machines to improve their efficiency. The improvement of machines is supplemented by experiments on production methods to measure the influence of differences in variety, stand of plants in the row, cultural methods, and the use of defoliants upon the harvesting performance by machines.

Harvesting machines are being studied as to their adaptability to farms differing in size, topography, soil type, variety of cotton, row spacing, plant spacing in the row, with and without defoliation, soil conservation practices and climatic conditions. Adjustments and modifications of machines and production methods are being made to improve the efficiency of harvesting and production. Comparisons are made of the performance of strippers and spindle-type pickers. The performance of strippers is studied under conditions of differences in roll types, the materials with which they are made, the roll speed and the width of throat. Newly developed varieties of cotton are tested for picker efficiency, general turnout, preharvest losses and trash content of harvested cotton.

While the agricultural engineer is concerned with the mechanical performance of machines in the harvesting process, the agricultural economists are directing their attention to the economics of cotton harvesting and its influence upon the farming system. Studies are under way to measure the influence of mechanical harvesting upon labor requirements, on the output per worker and the relative cost of production, the effects upon farm organization, operation and income on farms of various types and to appraise the current and potential importance of mechanization.

Careful physiological and histological studies of cotton in the laboratory, in the greenhouse and in the field are directed to the development of a better understanding of natural and induced abscission with the purpose of developing means for reducing the trash in mechanically harvested cotton due to the inclusion of leaf material. This work includes the use of chemicals to induce defoliation and retard secondary growth. Related physiological studies are concerned with the influence of chemical weed killers upon the vegetative part and root system of cotton, the chemical specificity and selectivity, the influence of chemical weed treatments on irrigation water and the influence of semipermanent soil sterilants.

Much of the current research on the mechanization of cotton has been initiated since 1947. The degree of cooperation, coordination and exchange of information by workers of the several subject-matter groups and administrative units gives promise of rapid progress in this field. Each succeeding year finds an increasing use of mechanized equipment in areas where the farm units are large and the topography suited to the use of machines.

Progress is also being made in the versatility of machines and in their adaptability to smaller farms.

Ginning Cotton

Research on the ginning of cotton has been active in the Department for several years. The establishment of the Ginning Laboratory in Mississippi during the 30's gave considerable impetus to this program. With the passage of the Research and Marketing Act of 1946 this program was extended to the dry areas of the Southwest. The program has been conducted in cooperation with States of the Cotton Belt to develop information on the principal varieties and sources. The program has also been correlated with the educational programs of the Extension Service whereby new information is taken to the ginners of the cotton states.

The separation of cotton lint from seed and trash under varying conditions of production and harvesting has created many new demands on the ginning process. The development of seed cotton dryers and cleaners and adjustments in saws, saw speeds, type of seed roll and other parts of the ginning equipment have helped to meet new demands. Studies of press equipment and design have made possible the packaging of higher density bales at the gin. Design of new dryers, conditioners, cleaners and modified ginning equipment have been made to synchronize the various pieces of equipment and study their performance in terms of cotton quality and economy. Associated research has developed an automatic sampling device to take samples representative of all parts of the bale and means of permanent bale identification.

The general objective of the current program is to increase the cotton growers' profits by developing better ginning equipment to produce a better grade of cotton and a higher price. More specifically the research aims to discover the fundamental laws of cotton conditioning, cleaning and extracting, ginning and baling. The research seeks to improve saw-gin stands with special reference to cleaning performance, the relationship of moisture levels of seed cotton to ginning, the development of a device for removing sticks, and the disposal of wastes. Other studies are concerned with the development of equipment for bulk seed cotton feeding control to prevent clogging and waste of time. Studies of cottonseed conditioning, cleaning and handling at the gin are made to improve the quality of seed for processing and seed purposes. Different gin processes and methods are evaluated for use on cotton grown in low humidity areas. Special studies are concerned with the control of static electricity in cotton gins particularly for the dry Southwest. Ginners and cotton growers are served by testing and adapting new gin equipment and techniques to different locations in the Cotton Belt. Other studies are made of roller ginning processes, equipment and techniques adapted to the ginning of machine-harvested Pima and other long staple cottons. Certain studies are directed to the development of improved equipment and techniques for cleaning cottonseed and linters from seed cotton that has been harvested mechanically.

Cooperative economic studies are active in the evaluation of cottonseed cleaning, the cost and quality of ginning in various areas, the development of automatic cottonseed sampling, and the effectiveness of cotton lint

cleaners under commercial gin operating conditions. Surveys are made to determine the adequacy of storage facilities for oil seeds and their products.

Studies are made of gin storage capacities under conditions of mechanical harvesting and the possibility of alleviating storage requirements by the marketing mechanically of harvested cotton in the form of seed cotton rather than lint. These studies also include the development of conditions favorable to the storage of mechanically-harvested cotton.

Cotton Marketing Research

Cotton has for many years been an important commodity in domestic and export trade in our country. It may pass through few or many hands in its trek from the grower to the manufacturer. The ginner may purchase the cotton and sell it directly to the mill or to intermediate dealers. Large growers and organized groups of growers may sell directly to the manufacturer or to intermediate groups of cotton merchants. Cotton merchants may collect cotton in large quantities and classify it according to the specifications of their mill customers. Warehousing and sales organizations of cotton cooperatives may also perform this service. Exporters maintain agents in Europe and other consuming areas to learn of the demands for cotton and how they can best serve their foreign customers.

The cotton marketing research program has sought to improve the marketing facilities and procedures. In fact all of the research dealing with cotton production, harvesting and processing is conscious of its relation to market quality of the crop. Basic to all market procedures is the matter of cotton grades and standards. Grades and standards should reflect utility and market value. Continuing studies are directed to the improvement of grades and standards and the precision with which they can be measured, and techniques for the measuring of the quality of cottonseed. The storage and marketing of cottonseed, market efficiency and costs, and basic statistics concerning supplies and demand are being studied.

The classing, grading and standardization research on cotton is directed to the development of equipment and techniques for measuring quality factors which influence use values and relating such information to standardization and testing. This development is also concerned with the maintenance of testing services for cotton breeders and others. The program is also concerned with improved methods for measuring the quality of cottonseed and other oil seeds. A part of this research seeks to develop a quick method for determining the oil content of cottonseed.

Cotton warehouses and warehouse equipment are being studied to improve warehouse equipment and handling techniques, warehouse design, layout, size, location, and method of operating various types of storage facilities and their relative costs. Studies of transportation are directed to an analysis of costs and the economic effects on agriculture and for the development of a general index on freight rates for agricultural products.

The storage and marketing of cottonseed particularly with reference to

planting seed is being studied by the Department and seven cooperating States representing different parts and conditions in the Cotton Belt. A better understanding of the marketing procedures for planting seed, the means of improvement, varieties of seed handled, the quality of seed and the adequacy of seed available to growers is sought. Careful studies are being made on the influence of storage conditions upon viability, the vigor of germination, the free fatty acid content, etc. Related studies seek information on the availability and quality of planting seed, farm practice in purchasing planting seed and market practices of producers of registered and certified seed. The information will also include records of the amount of registered and certified seed produced, the extra cost of production and the associated handling and processing practices.

The Department and eight State experiment stations are cooperating in a regional study of cotton marketing to relate cotton prices to growers, to quality and location of cotton, and to learn more about the buying practices and demands of mills. In these studies surveys are being conducted to identify marketing channels, facilities, agencies, services and charges associated with the market system. The surveys will include studies of marketing practices by farmers, owners and renters in the sale of upland and Delta cottons.

Local studies of cotton marketing are designed to compare marketing from one-variety communities with multiple-variety communities, and to test the value to growers of knowing the grade and staple of their cotton. The results of the survey will be analyzed to determine the factors affecting cotton prices at gin points and on local markets.

Basic statistics on supplies, demands, movement and consumption of cotton are important in the planning of production, the promotion of trade and utilization of cotton. Research workers of the Department and States are engaged in gathering, compiling and analyzing statistics on domestic and foreign cotton production and utilization. The data include cotton estimates and reports of acreage, yield per acre, production, stocks, farm disposition, utilization and other related items. Phases of this research are designed to improve the accuracy of estimates. Current efforts are made to collect data on export prospects, foreign production and factors affecting the demand for American cotton. This information is released in timely market news items on quality, price, stocks and market activity of cotton and cottonseed products. Current reports are issued on price, supply and consumption of cotton and rayon. Special services are rendered cotton and oilseed cooperatives concerning statistics on cooperative marketing and methods for improving the market operations of marketing associations.

An analysis of price risks for cotton and cotton products is being made with data collected during the period of 1935-41 and the period of 1947-53, relating to prices of spot cotton, selected yarns and fabrics and cotton futures contracts. The study is designed to show the protection afforded by futures contracts as hedges to farmers and merchants on one hand and to manufacturers on the other. The data will also relate futures trading to the stability of cotton prices.

Research relating to the marketing of manufactured products from cotton and cottonseed has been included with research on the utilization of cotton.

Comments. In closing this discussion on cotton marketing I would like to express an opinion regarding the current extensive surveys on the marketing of cotton, particularly those which recount grower practices and relationship of price to quality of cotton. I may be in error, although I have the impression that this type of study has been under way since 1913 or 1914, and that the general conclusions derived at that time have not been changed much by succeeding studies. Are there not more fundamental phases of the cotton marketing problem? For instance, what are the new services being offered by private marketing agencies to their customers? To what extent is this serving the needs of the manufacturers? What are they paying for this extra service? Are the manufacturers really seeking fineness of fibers in their cotton? Do they consider relative freedom from neps more important than fineness and its associated strength? There must be many approaches to a better understanding of the manufacturers' requirements.

Cotton Utilization Research

Cotton growers of the South have sought to extend the uses for cotton and cottonseed since the development of the cotton gin. The U. S. Commissioners of Patents published information on new uses for cotton and cottonseed in 1844 and 1845. The U. S. Department of Agriculture published information on the manufacture of cottonseed products in 1896. Between 1914 and 1938 research was conducted on the qualities and use of cotton and cottonseed. During this period considerable basic research was done toward the development of grades and standards and relating them to use performance. The Agricultural Adjustment Act of 1938, which authorized the Department of Agriculture to establish four regional research laboratories "to develop new and extended uses for agricultural commodities and their products", gave new hope for dealing with our cotton surplus. At the time of this development cotton was losing a part of its export market to foreign production and synthetic fibers, paper and plastics were making heavy inroads on the domestic market.

The Research and Marketing Act of 1946 included, among other purposes, the further expansion of research to develop new and extended uses for agricultural products. The program which followed has been well integrated and has recognized that research to improve utilization begins with production and extends through consumer utility and satisfaction. The team of research workers has included growers, public agencies of the Federal Government, the States and all branches of the industry.

American upland cotton had previously enjoyed some advantages on the export markets because of its higher quality. In recent years our position in this respect has not been too secure and the competition from synthetic fibers has grown stronger. When the recently accelerated research program was being planned it was agreed that improved quality would be an important factor in cotton's competition with other fibers and growths. The new

program therefore strengthened work to measure and analyze the components of cotton fiber quality and the best means of using these qualities in the construction of yarn and fabrics.

Research was started to develop new precision instruments for measuring fiber properties. These values have been correlated with spinning and other use values and those instruments and techniques which proved most useful have been made available to breeders to improve their breeding techniques and to manufacturers who wish to select raw cotton suited to special purposes. Attention has been given to the rapid measurement of such fiber properties as length, fineness, maturity, tensile strength, elasticity, drag, lustre, structure and adaptation to chemical modification. Studies for the improvement of methods for measuring pore size and distribution in textiles seek to evaluate fabrics for clothing, shelter filtration and protective covering. An instrument in the process of development would measure the nepping potentials of cotton samples prior to manufacture.

Factors Influencing Cotton Utilization. A group of economic studies is concerned with the identification and analysis of factors which affect the utilization of cotton. Comprehensive studies seek information on the qualities of cotton required for the manufacture of specific products, the relationship of such requirements to the fiber characteristics of the principal varieties of cotton now in commercial production in the United States and the approximate market outlet for each. Special analyses are made of factors affecting prices and utilization of cotton and cotton products. Estimates are made of domestic mill consumption, and special studies are directed to the improvements in the accuracy of the crop forecast. Research and service activities seek to discover means of improving the quality and reducing the cost of services involved in marketing textiles. Measurements and analyses of changes in margins and costs of marketing textiles are being made to relate changes in margins and costs to changes in price and other factors. In addition to supplying current statistics on the cotton industry this research contributes to the long-time economic statistical series on the industry. Active studies are directed to the improvement of consumption data analyses. Additional studies seek to develop a better understanding of the factors which affect total export of United States cotton and those which influence the major importing countries.

The entire field of fiber and fabric use is being explored to find opportunities where cotton may be made more useful to industry and other consumers. The research approaches include studies for the best uses of the natural properties of cotton, the use of additives to enhance service or attractiveness, and fiber modifications for adaptation to special uses. Basic to all of these objectives are the fundamental studies of physical and chemical structure of the fiber and its various reactions to physical and chemical treatment. The basic studies will become increasingly valuable to future applications to new and extended uses of cotton.

A survey of the industrial uses for cotton seeks to get a record of opinions and practices regarding the use of cotton and competing materials in electric insulation from manufacturers of insulated electric wire supplies, from suppliers of these manufacturers, from major distributors and underwriters.

New cottons such as those of inter-species hybrid origin and others that have demonstrated values of high strength and superior spinning values are studied to determine optimum processing conditions to speed commercial introduction and to provide improved cotton products.

Studies to improve the resistance of cotton fabrics to weather damage and microorganisms have sought to improve cotton materials for outdoor use such as awnings, tenting, plant bed covers, and tobacco shade cloth. Results of these studies have materially increased the life and service of such fabrics. The use of lead chromate, for example, has extended the life of tobacco shade cloth and plant bed cloth by protection from the action of light and other deteriorating influences.

To compete with other fibers in the manufacture of clothing and household fabrics, cotton must be versatile in its uses and adaptations. To improve its use in these fields studies are made of factors which influence the draping properties of cotton fabrics, including type of yarn construction, chemical and additive treatments and kind of weaving. Methods and equipment are being developed to measure the natural lustre of cotton and the best means by which lustre can be added through mercerization and as an aid to the selection of cotton best suited to mercerization, and other lustre-producing finishes. With the purpose of improving the serviceability of cotton fabrics for civilian and military use, studies are being made on the effect of yarn count, weave, and yarn number, and fabric design for these uses.

In personal surveys consumer opinions and experience with household fabrics are sought to guide future production. Such studies seek to determine whether rayon, rayon and cotton, or cotton-tufted bedspreads lint less and consumer reactions to the relative soil resistance of cotton rugs and woolen rugs. The serviceability of work dresses made from cotton percales differing in construction, length of staple, fineness of fiber and number of yarns per inch is being studied. Service tests of cotton sheets are being made of sheets laundered only, of sheets laundered and used, and of sheets made of cotton, rayon, and cotton and rayon.

Fabrics of known composition, construction and finish are studied under consumer use and the results interpreted in terms of utility and consumer satisfaction. Related studies are concerned with the wearing quality of garments when made from cottons differing in variety, origin and seasonal growth and the effects of method of laundering and personal wearing habits upon their durability. Two cottons of known history and differing in fiber properties have been converted into chambray, pique and madress dish towels and are being compared for utility after laundering and after laundering and use. Active studies are directed to the development of dry cleaning methods suited to cleaning and restoring freshness to cotton garments.

Chemical Modification of Cotton. The human trait of seeking variety in all natural and manufactured fibers finds a flexible medium in cotton. The Southern Regional Research Laboratory through its research has sought to advance our basic knowledge of the physical and chemical properties of the

cotton fiber and its reactions to chemical and physicochemical treatments.

The results of such studies have been applied to the development of methods for evaluating the bleaching, dyeing and mercerizing properties of different cottons and for determining the suitability of varieties for use in specific end products. Microscopical investigations of changes in the primary wall of the fiber due to chemical modification, commercial scouring and bleaching are being made to guide such treatments to the point of producing desired results without damaging the wall. Related studies are made of the changes in cotton fiber properties caused by acetylation and decrystallization to note their limitations and the possible use for heat resistant fibers. Additional studies are directed to the application of infra-red absorption techniques to the characterization of modified cotton and as a possible means of following changes which accompany aging or chemical treatment. The results of such studies are correlated with the use of X-ray as a measure of crystallinity in cotton cellulose.

Fabrics are being subjected to a routine of treatments with inorganic and metal-organic compounds which will deposit on or react with cellulose. Oxides of titanium, antimony and tin, insoluble mineral deposits and mineral dyes to improve light stability, durability, flame resistance and other physical properties suited to civilian and military uses are being studied. Treatments having promising responses are studied with reference to the mechanisms by which deposits produce their results and to discover means of producing linkage and cross-linkage with these materials. The use of chemically-treated bags is under study to note protective values against insects.

A series of several integrated experiments is directed to the development of treatments which will impart flame resistance to cotton fibers and fabrics. Pilot plant studies seek to develop a continuous process for the acetylation of cotton yarns and fabrics to produce textiles of improved heat, rot and acid resistance. Associated studies are concerned with means of controlling the extent of acetylation in the commercial production of these fabrics. Attempts are being made to discover means for the partial acetylation of raw cotton stocks and reconditioning to facilitate spinning. Basic studies seek a better understanding of the mechanism of the chemicals and reaction which impart flame resistance. Variables in cotton variety are studied in connection with the treatments. Acid and alkali resistance of treated fabrics are studied to perfect the process and to assure the optimum treatment for each important end use. Exploratory studies with other chemicals are directed to the discovery of wash-resistant treatments that will impart flame-proof properties to cotton materials and have resistance to weathering and light.

Other chemical treatments to impart new properties to cotton include aminized cotton to impart new properties of dye absorption and physical changes and the conversion of aminized cotton to flame-proofed textiles. Attention is being given to the development of water-repellant fabrics and to discover the basic reactions of resins and other compounds used for this purpose. This research not only identifies useful chemicals for the development of water-repellant fabrics but has marked other added properties which may prove useful in the search for fabrics having other utility requirements.

A group of studies is concerned with methods of decrystalization of cotton fibers and increasing the elastic recovery and other desirable properties by chemical cross linkage with resinous compounds.

Improved Textile Machinery and Techniques. Changes in labor costs, the development of new textile materials and the handling of mechanically harvested cotton has placed more emphasis on the development of labor-saving machines and those designed to handle cotton in a variety of conditions. Existing cotton machinery is studied to determine optimum conditions for their operation and to suggest modifications for improvement. New equipment is being developed to meet new requirements. Within this general group studies are directed to the better proportionment of drafts in the roving process and as a result of this study draft guides are being developed for cottons of short, medium and long staple cotton groups differing in fineness. The studies will determine the draft distribution of drawing frames which will contribute to the uniformity of sliver and roving. It is anticipated that the studies will derive a formula for drafting based upon fiber fineness and staple length that will more accurately determine the roving twist that will provide more uniform level of drafting and result in significant increases of processing efficiency and yarn quality. Related studies are concerned with the effect that fiber length and fineness have on physical properties of single and ply yarns.

Active studies are concerned with the development of a machine or machines suited to the cleaning of trashy lint at the mill. Previous studies and development of a cotton opener have found the basis of such a machine and further development is being sought. Work is also directed to the development of a new type of beater to replace the beater section of the conventional textile picker. Other studies seek to develop principles of cleaning based upon the rise of electrostatic forces or a combination of mechanical and electrostatic forces.

Those who planned the cotton utilization research program approached the problem with the view that the opportunities for expanding many smaller uses was greater than the development of a few large uses. Cotton had been priced out of the range of many large-scale uses. The development of lower costs in cotton production and manufacture may help some but under the present rate of developments cotton substitutes are increasing in use more rapidly than cotton. The opportunities for foreign outlets on the basis of normal trade are not encouraging. Available alternate enterprises although not inviting to cotton growers may prove the best use of land and resources in the near future.

Research on the Utilization of Cottonseed and Cottonseed Products

The current research program on cottonseed is concerned with basic and exploratory studies of the composition of the seed, variables that may be due to differences in varieties and changes that may be due to environment. Composition is traced through to the processed products to observe changes due to processing. Specific studies are concerned with cleaning

and conditioning of seed, storage and processing, the keeping quality of cottonseed oil and its products.

Results of the composition of seed as influenced by variety and environment are used to guide selection of seed stocks for maximum production in different areas and to classify seed qualities for oil processing and food use. Microorganisms are suspected as agents responsible for cottonseed deterioration, particularly the organisms that may be responsible for the formation of free fatty acids in the seed. Organisms found in and on the cottonseed are studied to note their identity, their functions and to test means of controlling those which contribute to the deterioration of the seed. Related studies seek to explore the enzyme systems of the seed and their possible connection with deterioration under unfavorable environment.

The characteristics of oils and meals made by different commercial processes are compared with the purpose of producing oils of improved quality and meals of higher nutritive value. This program includes the cooperation of biochemist and nutrition specialist to evaluate the chemical and nutritional properties of meals produced by various methods. The modifications of processing include variables in moisture added, cooking time and temperatures. Many of these studies require new techniques and controls for precision measurements. These must be developed as a part of the program. For instance, a rapid microbiological assay has been developed to determine the protein values in terms of the ten essential amino acids. Allergenic components of cottonseed protein have been isolated and identified and current studies seek to determine the effects of progressive enzymic hydrolysis as a counteractive measure to correct their harmful action.

Recent studies have sought to extend the use of cottonseed meal for human food by incorporating small quantities in baked foods such as bread, cookies and doughnuts. The studies have included the preparation of special meals, mixing and baking studies to develop suitable formulas and observation on consumer acceptance.

The nutritive values of cottonseed meals produced by commercial and modified commercial processes are studied by actual feeding tests. These trials include feeding experiments with rats, pigs, poultry and cattle to relate processing methods to animal and chick growth and egg yolk color.

National consumer preference surveys are under way to record the choice of household consumers for fats used in the home. These studies record and analyze statements of preference for lard, vegetable shortening, shortening compounds, margarine, butter and cooking oils. Related surveys are engaged in collecting information on the utilization of oilseed proteins for human food in institutions and in industry.

Cottonseed Oil Extraction. Three general principles are used in the extraction of oil from cottonseed: the hydraulic press, the screw press and solvent extraction. At the request of the industry these systems have been studied to improve their extracting efficiency and to improve the quality of oil and meal produced by them. Studies for improving the performance

of continuous screw pressing have tried variations in the severity of rolling the meats, differing the amount of water or steam added prior to or during cooking, varying the cooking temperature, controlling the cake temperature and the cake thickness and changes in shaft speed during processing. The influence of these variables upon the protein of the meal is measured by chemical analysis and assay and the influence on oil extraction is measured by the residual oil left in the meal, amount of color and refining loss and stability. Similar variables have been applied to the hydraulic press systems. The more favorable adjustments and procedures under pilot plant conditions are tested under commercial operations. Economic studies of the new processes and techniques adopted by the industry are studied to determine their influence on the oil processing industry, the market outlets and the returns to growers.

Engineers are conducting studies of different filtration extraction systems, including cost analysis, with the purpose of identifying systems suited to various conditions of the industry with emphasis upon the feasibility of the process for small mills. The research is being done in a pilot plant and includes variables in the preparation of the oilseed meals and observations on the effects upon yield and quality of oil and meal.

Cottonseed Oil. Research for the development of new and extended uses for cottonseed oil seeks to improve the quality of oil and to explore its chemical and physical properties to develop extended and new uses. One of the problems of quality concerns coloring material in the raw oil due to gossypol and other pigments which increase the cost of refining. Active studies are engaged in the development of processing methods for reducing the amount of pigment and by the isolation, identification and removal of pigments responsible for color in refined and bleached oils. The pigments of the oil are traced back to their origin in the seed.

Cottonseed oil is composed of a mixture of oils differing in chemical and physical properties. Fractions of these oils are found to have properties which fit them for special uses. Studies are under way to find methods and solvents that may be used to separate the different oils. Basic studies are seeking more information of the physical properties and reactions of fatty acids, fats and esters which may aid in the development of coatings, highly plastic fats and related products needed in industry. New types of fats are sought to supply the need for intravenous feedings, coatings and plasticising hard fats, waxes and polymers. Coatings are tested for water and air permeability to measure their adaptability to commercial uses. Other studies are concerned with the isolation and preparation of oils suited to the preparation of special emulsions.

Conclusions and Suggestions on Cotton Utilization Research. Phases of the cotton utilization research program have made outstanding contributions to the advancement of basic knowledge of the chemistry, physics and morphology of cotton fibers and seeds. The information has been correlated with cottons of known origin and growth so that it has not only contributed to a better understanding of utility but has advanced techniques for the development of improved varieties. This background of basic information will have a continuing value to the development of new and extended use of

cotton. More basic knowledge is needed and much work will be required to determine the significance of information already developed.

In the beginning of this report mention was made of the organized groups set up to plan broad attacks on certain cotton problems. In recent years several problems have received more intensive attack by virtue of the cooperation between two or more groups of scientists. Studies of changes in nutritive properties of cottonseed meal due to differences in processing is an illustration. Two or more groups have contributed to cooperative fiber studies. One concerned standardized laboratory techniques and another concerned the correlation of fiber quality with yarn and fabric quality. There are, no doubt, many other opportunities for cooperative effort. It is conceivable that greater resort to the study of fabrics and clothing in actual use would develop better techniques and provide better consumer information.

Some of the studies now under way are directed to the measurement of newly observed physical properties. It is likely that considerable improvement in the precision of processing will be required before the significance of these properties can be measured.

Review of some of the recently stated objectives of cotton breeders reveals that some of them are in search of coarser fibers that will "take more beating from textile machinery in cleaning and processing." There is also concern regarding the association of the tendency to form neps in some of the finer cottons. Our knowledge of the physiology of the cotton plant is still limited. Have we fully determined the influence of good farming upon fiber quality and use? Have we fully explored the advantages and disadvantages of fiber fineness in utilization?

In the past I fear that we have resorted to pilot plant operations before needed basic facts were available. This has been an expensive experience and may have prolonged rather than shortened the time of application. Many of our research contracts have included objectives which involved basic studies to be followed by the application of basic data to the development of mechanical equipment. It is suggested that more care be used in the selection of contractors to do basic research and that the basic and applied phases be made the subject of separate contracts, the applied phase to be undertaken only when adequate basic data is available.

